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Technical Review of Full Utility Navigation Demonstration (FUND) Phase 4

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13. ABSTRACT (Maximum 200 words) The Naval Research Laboratory's Mapping Sciences Branch was tasked by the Commander Naval Meteorology and Oceanography Command (CNMOC) and the National Imagery and Mapping Agency (NIMA) to perform software testing of the Full Utility Navigation Demonstration (FUND) software. The FUND software demonstrates the use of NIMA's Digital Nautical Chart (DNC) database within an Electronic Chart Display Information System (ECDIS). This report presents the results of the evaluation of the final Phase 4 FUND software.				
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TECHNICAL REVIEW OF FULL UTILITY NAVIGATION DEMONSTRATION (FUND) PHASE 4

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and the National Imagery and Mapping Agency (NIMA)

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1. INTRODUCTION

The Naval Research Laboratory's Mapping Sciences Branch has been tasked by the Commander Naval Meteorology and Oceanography Command (CNMOC) and the National Imagery and Mapping Agency (NIMA) to perform software testing of the Full Utility Navigation Demonstration (FUND) software. The FUND software demonstrates the use of NIMA's Digital Nautical Chart (DNC) database within an electronic charting system. The FUND software is currently under development by the Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering Division, Norfolk Detachment (NISE East Det Norfolk Code 35).

FUND software is being developed in four phases. This report presents the results of the evaluation of Phase 4. The FUND Phase 4 software is currently being ported to the Windows NT computer platform.

2. OVERVIEW

While the purpose of FUND is only to demonstrate the use of the DNC data product rather than to actually produce an Electronic Chart Display and Information System (ECDIS), the standards that have been produced by the International Maritime Organization (IMO) and the International Hydrographic Organization (IHO) provide a useful set of criteria against which the combination of the DNC database and the FUND software can be evaluated.

With the completion of Phase 4, FUND proves that DNC can be used in an ECDIS system. It presents a visually attractive nautical chart that meets most, but not all, of the IMO and IHO requirements. Significant shortfalls exist in chart updating, the route planning alarms, and the route monitoring off-track alarm, but overall, Phase 4 is very close to meeting all ECDIS requirements.

The functional capabilities of FUND using DNC were evaluated against the requirements set forth in the following:

1. Performance Standards for ECDIS, International Maritime Organization. Results are presented in Section 3 of the report. Paragraph numbers are prefixed with "PS" and refer to the numbering within the referenced document.
2. Specifications for Chart Content and Display aspects of ECDIS (S-52), International Hydrographic Organization. Results are presented in Section 4 of the report. Paragraph numbers are prefixed with "S52" and refer to the numbering within the referenced document.
3. Task Order, DMA to NISE-East, 10 April 95, FUND. Results are presented in Section 5 of the report. Paragraph numbers are prefixed with "T" and refer to the numbering within the referenced document.

The reader is encouraged to consult the three references for a full statement of the functional requirements.

Section 6 provides comments of a general nature relating to installation, documentation, and operation.

Section 7 describes the joint effort by Naval Research Laboratory (NRL) and the Naval Oceanographic Office to produce a prototype supplementary oceanographic layer in Vector Product Format (VPF) for use as a DNC overlay in FUND.

3. CORRELATION OF FUND PHASE 1 WITH IMO PERFORMANCE STANDARDS FOR ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEMS (ECDIS)

3.1 IMO Performance Standards ECDIS

REQUIREMENT	RATING	TEST PROCEDURE	EXPECTED RESULT	RESULT / COMMENTS
PS 1 INTRODUCTION				
PS 1.1 The primary function of the ECDIS is to contribute to safe navigation.		Non-testable requirement.		
PS 1.2 ECDIS, with adequate back-up arrangements, may be accepted as complying with the up-to-date charts required by regulation V/20 of the 1974 SOLAS Convention.		Non-testable requirement.		
PS 1.3 In addition to the general requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and the requirements for electronic navigational aids contained in IMO resolution A.694(17), ECDIS should meet the requirements of this performance standard.		Non-testable requirement.		

• IEC Publication 945.

PS 1.4 ECDIS should be capable of displaying all chart information necessary for safe and efficient navigation originated by, and distributed on the authority of, government-authorized hydrographic offices.	PASS	Add User Overlays to the ECDIS display by selecting menu item Chart / User Overlays / DNC.	All DNC features should be displayable.	Performed as expected; however, only DNC charts are supported. DX90 is not supported.
PS 1.5 ECDIS should facilitate simple and reliable updating of the electronic navigational chart.	FAIL	No update test data available.		
PS 1.6 Use of ECDIS should reduce the navigational workload as compared to use of a paper chart. It should enable the mariner to execute in a convenient and timely manner all route planning, route monitoring and positioning currently performed on paper charts. It should be capable of continuously plotting the ship's position.	MARGINAL	See individual tests in this document concerning IMO PS10.4 and PS10.5.		
PS 1.7 ECDIS should have at least the same reliability and availability of presentation as the paper chart published by government-authorized hydrographic offices.	PASS	Non-testable requirement.		FUND displays the DNC correctly; however, this is more of an issue of the correctness of the DNC.
PS 1.8 ECDIS should provide appropriate alarms or indications with respect to the information displayed or malfunction of the equipment (see Appendix 5).	MARGINAL	See review of PS Appendix 5 in this document.		
PS 3 DISPLAY OF SENC INFORMATION				

PS 3.1 ECDIS should be capable of displaying all SENC information.	PASS	(a) Follow procedures to add User Overlays. (b) Right-click mouse while holding cursor over any of the displayed SENC data.	(a) Features available to add to the display should include all those required by the data specification. (b) Window should appear displaying all spatial information for area queried.	Performed as expected.
PS 3.2 SENC information available for display during route planning and route monitoring should be subdivided into three categories, display base, standard display, and all other information (see Appendix 2).	PASS	Press F2, F3, and F4 to verify the Base, Standard, and Other Displays (respectively).	Each setting should display its required information as specified by PS Appendix 2.	Performed as expected.
PS 3.3 When a chart is first displayed on ECDIS, it should provide the standard display at the largest scale available in the SENC for the displayed area.	PASS	Press F3 to get the Standard display.	Information displayed should be representative of that specified by the Standard Display (see PS Appendix 2).	Performed as expected.
PS 3.4 When a chart is first displayed on ECDIS, it should provide the standard display at the largest scale available in the SENC for the displayed area.	PASS	Load a FUND Demo, verify that the Standard Display is the current setting and that the chart displayed is the largest scaled chart available for that area. (The user can verify the chart displayed by comparing the gray text at the lower right of screen with the library diagram on the back of the CD Case).	Top-left corner of user interface should display "Standard" and the chart scale should be the largest available for that area.	Performed as expected.
PS 3.5 It should be easy to add or remove information from the ECDIS display. It should not be possible to remove information contained in the display base.	PASS	Add/Delete User Overlays to/from the ECDIS display by selecting menu items Chart / User Overlays / DNC.	User Overlays should be displayed (Add) and removed (Delete) from display. Should in no way be able to remove the information contained in the base overlay.	Performed as expected.

PS 3.6 It should be possible for the mariner to select a safety contour from the depth contours provided by the SENC. ECDIS should give the safety contour more emphasis than other contours on the display.	FAIL	Non-supported requirement.		FUND does not allow the mariner to set a safety contour but automatically assigns the safety contour as the shoalest contour that is deeper than the ship draft.
PS 3.7 It should be possible for the mariner to select a safety depth. ECDIS should emphasize soundings equal to or less than the safety depth whenever spot soundings are selected for display.	MARGINAL	Select menu item Ship / Draft and choose a draft selection.	While running a demo route, sounding shoaler than the ship's draft will highlighted.	Performed as expected; however, the mariner can only set the ship's draft, not an actual safety depth.
PS 3.8 The ENC and all updates to it should be displayed without any degradation of their information content.	MARGINAL	Display ENC data and updates for various locations.	ENC data and all updates should be displayed without any degradation of information content.	ENC data looks correct but no ensuring means of verifying data validity; unable to test updates due to unavailability of update data.
PS 3.9 ECDIS should provide a means of ensuring that the ENC and all updates to it have been correctly loaded into the SENC.	FAIL	No update test data available.		
PS 3.10 The ENC data and updates to it should be clearly distinguishable from other displayed information, such as, for example, that listed in Appendix 3.	PASS	View the display to determine if the ENC data is distinguishable from other displayed information.	ENC data should be distinguishable from other displayed information	Performed as expected.
PS 4 PROVISION AND UPDATING OF CHART INFORMATION				
PS 4.1 The chart information to be used in ECDIS should be the latest edition of information originated by a government-authorized hydrographic office, and conform to IHO standards.	PASS	Compare fully updated ECDIS display with fully updated paper chart.	All chart features match and all updates are consistent between the paper chart and the ECDIS.	Performed as expected.

PS 4.2 The contents of the SENC should be adequate and up-to-date for the intended voyage, as required by regulation V/20 of the 1974 SOLAS Convention.	MARGINAL	See questions (concerning update data).		
PS 4.3 It should not be possible to alter the contents of the ENC.	PASS	Verify that the ENC media is read only.	The CDROM media is read only	Performed as expected.
PS 4.4 Updates should be stored separately from the ENC.	PASS	Verify that the ENC media is read only, thus assuring that the updates are stored separately.	The CDROM media is read only	Performed as expected.
PS 4.5 ECDIS should be capable of accepting official updates to the ENC data provided in conformity with IHO standards. These updates should be automatically applied to the SENC. By whatever means updates are received, the implementation procedure should not interfere with the display in use.	FAIL	No update test data available.		
PS 4.6 ECDIS should also be capable of accepting updates to the ENC data entered manually with simple means for verification prior to the final acceptance of the data. They should be distinguishable on the display from ENC information and its official updates, and not affect display legibility.	FAIL	No update test data available.		
PS 4.7 ECDIS should keep a record of updates, including time of application to the SENC.	FAIL	No update test data available.		

PS 4.8 ECDIS should allow the mariner to display updates so that the mariner may review their contents and ascertain that they have been included in the SENC.	FAIL	No update test data available.		
PS 5 SCALE				
PS 5.1 ECDIS should provide an indication of whether the information is displayed at a larger scale than that contained in the ENC.	MARGINAL	Turn off route monitoring and zoom in.	The Overscale alarm appears (letter 'O' displayed near upper-right corner of screen)	Must zoom in twice before the overscale indicator appears.
PS 5.2 ECDIS should provide an indication of whether own ship's position is covered by an ENC at a larger scale than that provided by the display.	MARGINAL	Turn off route monitoring and zoom out.	The Underscale alarm appears (letter 'U' displayed near upper-right corner of screen)	Must zoom out twice before the underscale indicator appears.
PS 6 DISPLAY OF OTHER NAVIGATIONAL INFORMATION				
PS 6.1 Radar information or other navigational information may be added to the ECDIS display. However, it should not degrade the SENC information, and should be clearly distinguishable from the SENC information.	PASS	Simulation test: While running in demo mode, turn on ARPA using the following sequence: Select menu item FUND / Demo, select menu item Edit / ARPA, click on a row in the table, and select Tracking to be 'ON'. At sea test: With the ECDIS connected to the radar system. Turn on ARPA as before.	The contacts appear and behave as indicated in the ARPA demo table.	Performed as expected.
PS 6.2 ECDIS and added navigational information should use a common reference system. If this is not the case, an indication should be provided.	PASS		The Contacts are plotted correctly in relation to own ship.	Performed as expected.
PS 6.3.1 Transferred radar information may contain both the radar image and ARPA information.	PASS	Turn on ARPA as before.	The Contacts are plotted correctly in relation to own ship.	Performed as expected; radar image not supported.

PS 6.3.2 If the radar image is added to the ECDIS display, the chart and the radar image should match in scale and in orientation.		Non-testable requirement.		
PS 6.3.3 The radar image and the position from the position sensor should both be adjusted automatically for antenna offset from the conning position.		Non-testable requirement.		
PS 6.3.4 It should be possible to adjust the displayed position of the ship manually so that the radar image matches the SENC display.		Non-testable requirement.		
PS 6.3.5 It should be possible to remove the radar information by single operator action.	FAIL	Non-supported requirement.		Can only turn ARPA points off one at a time.
PS 7 DISPLAY MODE AND GENERATION OF THE NEIGHBOURING AREA				
PS 7.1 It should always be possible to display the SENC in a "north-up orientation. Other orientations are permitted.	PASS	Verify that the interface for display is north up.	North is up.	Performed as expected.
PS 7.2 ECDIS should provide for true motion mode. Other modes are permitted.	PASS	Examine the user interface for motion modes. Choose them and note behavior.	True motion should be supported.	Menu / Chart / Configuration / Motion / Relative and Non-Relative are provided. Relative mode keeps the ship at the center. Non-relative moves the ship across the chart.
PS 7.3 When true motion mode is in use, reset and generation of the neighboring area should take place automatically at a distance from the border of the display determined by the mariner.	PASS	Set mode to Non-relative.	Chart is re-centered when ship nears chart edge.	Performed as expected.

PS 7.4 It should be possible manually to change the chart area and the position of own ship relative to the edge of the display.	PASS	Set mode to Non-relative while route monitoring. Using the mouse, drag a corner of the dashed rectangle to a new position.	Own ship position is maintained within the resized rectangle.	Performed as expected.
PS 8 COLORS AND SYMBOLS				
PS 8.1 IHO recommended colors and symbols should be used to represent SENC information*.	MARGINAL	See review of S52 Appendix 2 in this document.	FUND should use the colors given in the appendix.	While FUND produces an excellent display looking very much like paper charts, some discrepancies were noted.
PS 8.2 The colors and symbols other than those mentioned in 8.1 should be those used to describe the navigational elements and parameters listed in Appendix 3 and published by IEC**.	PASS	Compare symbol colors for navigational elements listed in PS Appendix 3 with S52 Appendix 2 - Table 1.	Navigational element colors differ from DNC colors.	Performed as expected.
PS 8.3 SENC information, when displayed at the scale specified in the ENC, should use the specified size of symbols, figures and letters mentioned in 8.1 and 8.2.		Did not have access to Presentation Library which defines the symbol sizes.		
PS 8.4 ECDIS should allow the mariner to select whether own ship is displayed in true scale or as a symbol.	MARGINAL	This functionality is not a user setting in FUND; however, charts displayed at large scales (harbor charts) have the ship displayed at true scale.		Map scale determines whether the ship is displayed in true scale or as a symbol.
PS 9 DISPLAY REQUIREMENTS				

* Appendix 3 to IHO Special Publication S-52.

** IEC Publication 1174.

PS 9.1.1 ECDIS should be capable of displaying information for route planning and supplementary navigation tasks.	PASS	Examine the user interface for route planning and supplementary navigation support.	Route planning and supplementary navigation tasks are supported	Performed as expected. Move cursor to a desired waypoint position. Press the hotkey "w" to create a waypoint. Use menu command Navigation / Planned Route / Save Route / Save Primary to save the route.
PS 9.1.2 ECDIS should be capable of displaying information for route monitoring.	PASS	Examine the user interface for route monitoring support.	Route monitoring supported	Performed as expected. Use menu command Chart / Configuration/ Route Monitoring or hotkeys F5 and F6.
PS 9.2 The effective size of the chart presentation for route monitoring should be at least 270 mm by 270 mm.	PASS	Measure the screen.	Should be at least 270mm by 270 mm.	Performed as expected.
PS 9.3 The display should be capable of complying with the color and resolution recommendations of IHO*.	PASS	Compare number of display colors with IHO recommendations.	Must have at least 64 colors per S52 Appendix 2 Section 5.1	Performed as expected.
PS 9.4 The method of presentation should ensure that the displayed information is clearly visible to more than one observer in the conditions of light normally experienced on the bridge of the ship by day and by night.	PASS	Test subjectively with more than one person.	Displayed information can be seen clearly by more than one person.	
PS 10 ROUTE PLANNING, MONITORING AND VOYAGE RECORDING				

* Appendix 2 to IHO Special Publication S-52.

PS 10.1 It should be possible to carry out route planning and route monitoring in a simple and reliable manner.	PASS	Exercise the route planning and route monitoring capabilities	Route planning and route monitoring should be simple and reliable	Performed as expected, except that to clear the current route, one must individually tag and delete each waypoint. A command to clear the current route should be provided. Occasionally while performing route planning and route monitoring concurrently FUND gets stuck on an update loop and has to be terminated.
PS 10.2 ECDIS should be designed following ergonomic principles for user-friendly operation.	PASS	Review all FUND operations for ease of use.	Operations should be easy to use.	Performed as expected; however, adding user overlays could be more streamlined.
PS 10.3 The largest scale data available in the SENC for the area given should always be used by the ECDIS for all alarms or indications of crossing the ship's safety contour and of entering a prohibited area, and for alarms and indications according to Appendix 5.	PASS	Navigate Through a harbor or approach chart and manually select a general chart.	Alarms should be based on larger scaled charts.	Performed as expected.
PS 10.4.1 It should be possible to carry out route planning including both straight and curved segments.	PASS	Create widely spaced waypoints. Set the line type using menu command Navigation / Planned Route / View Route / View Primary.	Route legs should be drawn either straight or curved (great circle)	Both rhumb line and great circle legs are correctly shown as curved legs on FUND's cylindrical equidistant projection. Paper charts are usually on Mercator projection where rhumb lines appear straight.
PS 10.4.2.1 Possible to adjust a planned route by adding waypoints to a route.	PASS	Position the cursor at the desired location and press 'w'.	A waypoint should be displayed on the screen and appended to the waypoint list.	Performed as expected.
PS 10.4.2.2 Possible to adjust a planned route by deleting waypoints from a route.	PASS	Move cursor to the waypoint. Press "r" key. to tag and the "backspace" key to delete.	The waypoint is deleted	Performed as expected.

PS 10.4.2.3 Possible to adjust a planned route by changing the position of a waypoint.	PASS	Move cursor to the waypoint. Press "q" key. Move cursor to new position and the "q" key to move the waypoint.	The waypoint is moved	Performed as expected.
PS 10.4.2.4 Possible to adjust a planned route by changing the order of the waypoints in the route.	PASS	Navigation / Planned Route / Reverse Route / Primary Route	The waypoint order is reversed	As expected. To reorder part of a route, waypoints must be deleted and recreated.
PS 10.4.3 It should be possible to plan an alternative route in addition to the selected route. The selected route should be clearly distinguishable from the other routes.	PASS	Open both primary and secondary routes.	Routes should be distinguishable. (Primary route appears in red, secondary in orange.)	Performed as expected.
PS 10.4.4 An indication is required if the mariner plans a route across an own ship's safety contour.	FAIL	Place waypoints such that the route goes over the safety contour.	An indication should appear.	No indication appeared.
PS 10.4.5 An indication is required if the mariner plans a route across the boundary of a prohibited area or of a geographical area for which special conditions exist (see Appendix 4).	FAIL	Place waypoints such that the route goes over a prohibited or special condition area.	An indication should appear.	No indication appeared.
PS 10.4.6 It should be possible for the mariner to specify a limit of deviation from the planned route at which activation of an automatic off-track alarm should occur.	FAIL	Non-supported requirement.		
PS 10.5.1 For route monitoring, the selected route and own ship's position should appear whenever the display covers that area.	PASS	While running a demo route, turn on route monitoring using menu item Chart / Configuration / Route Monitoring.	Own ship and route should appear on display.	Performed as expected.

PS 10.5.2 It should be possible to display a sea area that does not have the ship on the display (e.g., for look ahead, route planning), while route monitoring. If this is done on the display used for route monitoring, the automatic route monitoring functions (e.g., updating ship's position, and providing alarms and indications) should be continuous. It should be possible to return to the route monitoring display covering own ship's position immediately by single operator action.	MARGINAL	Turn off route monitoring (key "F6"), click the left mouse button to get display a location rectangle. Click the middle mouse button to shrink the location rectangle. Move the location rectangle to an area just ahead of the ship and click the left mouse button to display the area covered by the location rectangle.	The ship is off screen but the flashing hazard alarms appear.	As expected. Since alarms appear as flashing features on the chart, there is no indication when the features causing the alarm are off the screen. An additional sound or non-geographic screen indication would resolve this problem.
PS 10.5.3 ECDIS should give an alarm if the ship, within a specified time set by the mariner, is going to cross the safety contour.	FAIL	Use menu command Ship / Looking Ahead to set the time.	Contours should flash if the contour depth equals the safety contour or shoaler.	All contour lines in the path of the ship flash.
PS 10.5.4 ECDIS should give an alarm or indication, as selected by the mariner, if the ship, within a specified time set by the mariner, is going to cross the boundary of a prohibited area or of a geographical area for which special conditions exist (see Appendix 4).	PASS	Use menu command Ship / Looking Ahead to set the time.	Features ahead of the ship should flash.	Performed as expected.
PS 10.5.5 An alarm should be given when the specified limit for deviation from the planned route is exceeded.	FAIL	Non-supported requirement.		

PS 10.5.6 The ship's position should be derived from a continuous positioning system of an accuracy consistent with the requirements of safe navigation. Whenever possible, a second independent positioning method of a different type should be provided; ECDIS should be capable of identifying discrepancies between the two systems.	MARGINAL	Attempt to turn on both GPS and dead reckoning using menu command Interface / Position Source.	Both position sources should be turned on.	Only one position source at a time can be selected. The GPS interface was not tested.
PS 10.5.7 ECDIS should provide an indication when the input from the position-fixing system is lost. ECDIS should also repeat, but only as an indication, any alarm or indication passed to it from a position-fixing system.	PASS	Use Interface / Navigation Status to show the status.	OFFLINE shows in red when no GPS solution was computed.	Performed as expected.
PS 10.5.8 An alarm should be given by ECDIS if the ship, within a specified time or distance set by the mariner, is going to reach a critical point on the planned route.	FAIL	Demo a planned route.	An alarm should be given when the ship approaches a waypoint.	No alarm is given when a ship approaches a waypoint.
PS 10.5.9 The positioning system and the SENC should be on the same geodetic datum. ECDIS should give an alarm if this is not the case.	FAIL	Non-supported requirement.		FUND, DNC, and the GPS positioning system all have WGS84 as the geodetic datum.

PS 10.5.10 It should be possible to display an alternative route in addition to the selected route. The selected route should be clearly distinguishable from the other routes. During the voyage, it should be possible for the mariner to modify the selected sailing route or change to an alternative route.	PASS	Open or draw both primary and secondary routes. Use menu command Navigation / Planned Route / Switch routes.	The routes switch colors. The primary route becomes the secondary route and vice versa.	Performed as expected.
PS 10.5.11.1 It should be possible to display time-labels along ship's track, manually on demand and automatically at intervals selected between 1 and 120 m.	PASS	Use menu command Navigation / Track History / Configuration. Check "Display Primary Time Marks". Check and set Auto Interval	Time labels are displayed as specified.	Performed as expected.
PS 10.5.11.2 It should be possible to display an adequate number of points, free movable electronic bearing lines, variable and fixed-range markers and other symbols required for navigation purposes and specified in Appendix 3.	PASS	Use menu command Chart / User Overlays / Mariner to draw the desired features.	Desired features can be drawn.	Performed as expected.
PS 10.5.12 It should be possible to enter the geographical coordinates of any position and then display that position on demand. It should also be possible to select any point (features, symbol or position) on the display and to read its geographical coordinates on demand.	MARGINAL	Entering a geographical position for display is a non-supported requirement. However, the user may move the pointer over a point on the display.	The approximate geographical coordinates of the point directly under the pointer will be displayed.	Performed as expected.

PS 10.5.13 It should be possible to adjust the ship's geographical position manually. This manual adjustment should be noted alpha-numerically on the screen, maintained until altered by the mariner, and automatically recorded.	MARGINAL	Use the dead-reckoning functionality.	Should move the ship to input location.	The dead-reckoning performed as expected; however, the user should be able to simply enter the desired coordinates and the ship will be displayed at that location.
PS 10.6.1.1 To ensure a record of own ship's past track: time, position, heading, and speed should be recorded at one-minute intervals for the previous 12 hours.	PASS	Use menu command Navigation / Track History / Configuration. Select "12 Hours" under heading Track Display Duration. Select "1 Minute" under heading Time Markers. Press OK. Use menu command Navigation / Track History / View to see ship's record.	Ship's location every minute for the last 12 hours will be shown.	Performed as expected.
PS 10.6.1.2 To ensure a record of official data used: ENC source, edition, date, cell and update history.	FAIL	Non-supported requirement.		Unable to find a record of the official data used.
PS 10.6.2 In addition, ECDIS should record the complete track for the entire voyage, with time marks at intervals not exceeding 4 hours.	MARGINAL	Run a demo or dead-reckoning for several hours.	A log and track of the voyage should be kept.	Track and time marks was not displayed on the screen after 12 hours; otherwise performed as expected.
PS 10.6.3 It should not be possible to manipulate or change the recorded information.	PASS	Attempt to delete information out of the View Track History Window.	Should not be able to delete the information.	Performed as expected.
PS 10.6.4 ECDIS should have the capability to preserve the record of the previous 12 hours and of the voyage track.	PASS	Same as 10.6.1.1	Same as 10.6.1.1	Performed as expected.
PS 11 ACCURACY				

PS 11.1 The accuracy of all calculations performed by ECDIS should be independent of the characteristics of the output device and should be consistent with the SENC accuracy.	PASS	Unable to test; developer assures that calculations are performed in geographic space rather than pixel space.		
PS 11.2 Bearings and distances drawn on the display, or those measured between features already drawn on the display, should have an accuracy no less than that afforded by the resolution of the display.	MARGINAL	Create a route. Compare distance and bearing between the waypoints on the route using NIMAMUSE 1.1 application program.	Bearings and distances should be consistent.	Bearings between the two programs are similar but the distance between points varies plus or minus 6%.
PS 12 CONNECTIONS WITH OTHER EQUIPMENT*				
PS 12.1 ECDIS should not degrade the performance of any equipment providing sensor inputs. Nor should the connection of optional equipment degrade the performance of ECDIS below this standard.		Unable to test due to test configuration.		
PS 12.2 ECDIS should be connected to systems providing continuous position-fixing, heading and speed information.		Non-testable requirement.		
PS 13 PERFORMANCE TESTS, MALFUNCTION ALARMS AND INDICATIONS				
PS 13.1 ECDIS should be provided with means for carrying out on-board tests of major functions either automatically or manually. In case of a failure, the test should display information to indicate which module is at fault.	PASS	Use the included Demo capability to simulate route monitoring of a planned route.	Should follow planned route and alert user with alarms just like if it was really monitoring the ship.	Performed as expected.

* IEC Publication 1162.

PS 13.2 ECDIS should provide a suitable alarm or indication of system malfunction.	FAIL			During all the testing for this software review, the program never gave any indication in regard to a malfunction even though the program crashed a few times.
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3.2 PS Appendix 2: SENC Information Available for Display During Route Planning and Route Monitoring

REQUIREMENT	RATING
1 Display base, permanently retained on the ECDIS display, consisting of:	
1.1 coastline (high water);	PASS
1.2 own ship's safety contour, to be selected by the mariner;	MARGINAL
1.3 indication of isolated underwater dangers at depths of less than the safety contour which lie within the safe waters defined by the safety contour;	PASS
1.4 indication of isolated dangers which lie within the safe water defined by the safety contour such as bridges, overhead wires, etc., including buoys and beacons, whether or not these are being used as aids to navigation;	PASS
1.5 traffic routing systems;	PASS
1.6 scale, range, orientation and display mode;	PASS
1.7 units of depth and height.	PASS
2 Standard display, to be displayed when the chart is first displayed by ECDIS, consisting of:	
2.1 display base	PASS
2.2 drying line	PASS
2.3 indication of fixed and floating aids to navigation	PASS
2.4 boundaries of fairways, channels, etc.	PASS
2.5 visual and radar conspicuous features	PASS
2.6 prohibited and restricted areas	PASS
2.7 chart scale boundaries	PASS
2.8 indication of cautionary notes	PASS
3 All other information, displayed individually on demand, for example:	
3.1 spot soundings	PASS
3.2 submarine cables and pipelines	PASS
3.3 ferry routes	PASS
3.4 details of all isolated dangers	PASS
3.5 details of aids to navigation	PASS
3.6 contents of cautionary notes	PASS
3.7 ENC edition date	PASS
3.8 geodetic datum	FAIL
3.9 magnetic variation	PASS
3.10 graticule	FAIL
3.11 place names	PASS

3.3 PS Appendix 3: Navigational Elements and Parameters

REQUIREMENTS	RATING
1 Own ship	
1.1 Past track with time marks for primary track	PASS
1.2 Vector for course and speed made good	PASS
2 Vector for course and speed made good	PASS
3 Variable range marker and/or electronic bearing line	PASS
4 Cursor	PASS
5 Event	
5.1 Dead reckoning position and time (DR)	PASS
5.2 Estimated position and time (EP)	MARGINAL
6 Fix and time	PASS
7 Position line and time	PASS
8 Transferred position line and time	
8.1 Predicted tidal stream or current vector with effective time and strength (in box)	PASS
8.2 Actual tidal stream or current vector with effective time and strength (in box)	PASS
9 Danger highlight	PASS
10 Clearing line	PASS
11 Planned course and speed to make good. Speed is shown in box	PASS
12 Waypoint	PASS
13 Distance to run	PASS
14 Planned position with date and time	PASS
15 Visual limits of lights arc to show rising/dipping range	PASS
16 Position and time of "wheelover"	PASS

3.4 PS Appendix 4: Areas For Which Special Conditions Exist

The following are areas which ECDIS should provide an alarm or indication under 10.4.5 (route planning) or 10.5.4 (route monitoring). Note that no alarms or indications are implemented for route planning.

SPECIAL CONDITION AREAS	RATING (10.4.5)	RATING (10.5.4)
Traffic separation zone	FAIL	PASS
Traffic routing scheme crossing or roundabout	FAIL	PASS
Traffic routing scheme precautionary area	FAIL	PASS
Two-way traffic route	FAIL	PASS
Deepwater route	FAIL	PASS
Recommended traffic lane	FAIL	PASS
Inshore traffic zone	FAIL	PASS
Fairway	FAIL	PASS
Restricted area	FAIL	PASS
Caution area	FAIL	PASS
Offshore production area	FAIL	PASS
Areas to be avoided	FAIL	PASS
Military practice area	FAIL	PASS
Seaplane landing area	FAIL	Data not found.
Submarine transit lane	FAIL	PASS
Ice area	FAIL	Data not found.
Channel	FAIL	PASS
Fishing ground	FAIL	PASS
Fishing prohibited	FAIL	PASS
Pipeline area	FAIL	PASS
Cable area	FAIL	PASS
Anchorage area	FAIL	PASS
Anchorage prohibited	FAIL	PASS
Dumping ground	FAIL	PASS
Spoil ground	FAIL	PASS
Dredged area	FAIL	PASS
Cargo transshipment area	FAIL	PASS
Incineration area	FAIL	Data not found.
Specially protected areas	FAIL	PASS

3.5 PS Appendix 5: Alarms And Indicators

SECTION	RATING	REQUIREMENTS	INFORMATION
10.3	PASS	Alarm or Indication	Largest scale for alarm
10.4.6	FAIL	Alarm	Exceeding off-track limits
10.5.3	FAIL	Alarm	Crossing safety contour
10.5.4	PASS	Alarm or Indication	Area with special conditions
10.5.5	FAIL	Alarm	Deviation from route
10.5.8	FAIL	Alarm	Approach to critical point
10.5.9	FAIL	Alarm	Different geodetic datum
13.2	FAIL	Alarm or Indication	Malfunction of ECDIS
5.1	MARGINAL	Indication	Information overscale
5.2	MARGINAL	Indication	Larger scale ENC available
6.2	PASS	Indication	Different reference system
10.4.4	FAIL	Indication	Route planning across safety contour
10.4.5	FAIL	Indication	Route planning across specified area
10.5.7	PASS	Indication	Positioning system failure
13.1	PASS	Indication	System test failure

4. CORRELATION OF FUND PHASE 1 WITH SPECIFICATIONS FOR CHART CONTENT AND DISPLAY ASPECTS OF ECDIS (IHO S-52, DECEMBER 1994)

4.1 S-52: IHO Specifications for Chart Content and Display of ECDIS

Requirement	Rating	Test Procedure	Expected Result	RESULT / COMMENTS
S52 3.3.a Manufacturer of ECDIS may design own storage format of ENC data to allow system to meet performance requirements.		Non-testable requirement.		
S52 3.3.b ECDIS should accept and convert Hydrographic Organization data to own data.	PASS	Verify that FUND loads and displays DNC data.	Data is displayed correctly	Performed as expected.
S52 3.3.c Conversion accomplished in the ECDIS.	PASS	Verify that FUND loads the data only once for each DNC library.	Data is loaded only once.	Performed as expected.
S52 3.3.d Original ENC data should be kept onboard.		Non-testable requirement.		
S52 3.4.a If the area covered by the ECDIS display includes waters for which no HO ENC at a scale appropriate for navigation exists, the areas representing those waters should carry an indication to the mariner to refer to the paper chart.	FAIL	Dead Reckoning from point (0,0) with a heading of 290.	Prompt for load of DNC; if FUND doesn't get the data, should tell the user to refer to the paper chart.	Did not get any type of note to refer to a paper chart.
S52 3.4.b Should the manufacturer of the ENC data use point reduction or smoothing operations in order to compress the chart information in the SENC, the resultant image of the chart displayed at ENC scale should not differ from the ENC image by more than the display resolution.	PASS	Compare display precision with paper chart.	Display appears as precise as paper chart.	Performed as expected.

S52 3.4.c If the mariner does not specify a safety contour, this should default to 30 m. If the safety contour specified by the mariner is not in the SENC, the safety contour shown should default to the next deeper contour. If the safety contour in use becomes unavailable due to a change in source data, the safety contour should default to the next deeper contour. In each of the above cases, the mariner should be informed.	MARGINAL	(a) Run FUND without setting the safety contour (b) Set the safety contour.	(a) Safety contour should default to 30m (b) Safety contour should be set to whatever is the user's safety contour.	The safety contour seems to always be set at 30m.
S52 3.5.a ENC data should be assigned to a selection of scale ranges.		Non-testable requirement.		
S52 3.5.b Only one dataset is provided for each scale range. That dataset should always be populated from the largest scale data available within that scale range.	PASS	Verify that DNC is so constructed.	DNC is so constructed.	Performed as expected.
S52 3.5.c Data shown on the display should always be of the same scale. If a scale boundary is shown on the display, the information shown in the overscale area should not be relied upon at the scale of the display.	MARGINAL	Display data of different scales.	Should be specified to the user where the different scaled data meets.	FUND shows a dotted line but does not indicate to the user which data is what scale.
S52 3.6 ENC data should be organized in cells, both for data manipulation in ECDIS, and for chart correction.	PASS	Verify that DNC is tiled.	DNC is tiled.	Performed as expected.
S52 3.7 Language.	PASS	Verify that information is displayed in the English Language.	Information should be displayed in the English Language.	Performed as expected.

S52 4 Updates	FAIL	No update test data available.		
S52 5.1 Display categories for chart information are Display Base, Standard Display, and all other information.	PASS	Press F2, F3, and F4 to verify the Base, Standard, and Other Displays (respectively).	Each setting should display its required information as specified in Table IV of Appendix 2.	Performed as expected.
S52 5.2 ECDIS display-general.		Non-testable requirement.		
S52 5.3 Priority layers.	PASS	Verify that the data layers are displayed in the priority order required.	Data layers should be displayed in the required order.	Performed as expected.
S52 6.1 Only one horizontal datum should be used. This datum should be WGS-84.	PASS	Verify that DNC uses a single horizontal datum.	Uses a single horizontal datum.	Performed as expected.
S52 6.2 ENC should define each area for which a particular vertical datum applies.		Non-testable requirement.		
S52 6.3 a If data from different scales (density) appears on the display, the boundary between different scales should be clearly indicated. The ENC should define each area for which a particular compilation scale applies. It is this scale that should be used when deciding if data are being displayed overscale. A graphical index of the scale boundaries of available data should be shown on demand.	MARGINAL	Display data of different scales.	Should be specified to the user where the different scaled data meets.	FUND shows a dotted line but does not indicate to the user which data is what scale.
S52 6.3 b Ability to use intermediate scales or zoom in between scales.	MARGINAL	Try to use intermediate scales or zoom in between scales.	Should be able to use intermediate scales or zoom in between scales.	Can only change given scale when not in route monitoring.

S52 6.3 c A scale bar should be provided as part of the display base for navigating on a large scale (1:80,000 and larger). This is intended to give an immediate impression of scale and of the proximity of charted objects, rather than for accurate distance measurement, which should be made by means of the cursor. For chart displays at a scale smaller than 1:80,000, a latitude bar should be shown on the border of the standard display.	MARGINAL	Find scale bar on left side of display and locate latitude bar.	Should find scale bar and for chart displays at a scale smaller than 1:80000, should find a latitude bar.	Scale bar is visible at all scales; did not find a latitude bar.
S52 6.4 Position units are latitude and longitude in degrees, minutes, and decimal minutes. Depth units are meters and decimeters. Height units are meters. Distance units are nautical miles and decimal miles, or meters. Speed units are knots and decimal knots.	PASS	Verify that the units on the display are correct and obvious to the user.	The units on the display should be correct and obvious to the user.	Performed as expected.
S52 6.5 Standard legend of general information should be available for display on a graphic or text display.	MARGINAL	Verify that a standard legend of general information is shown.	A standard legend of the general information should be shown.	Was no legend data for sounding/vertical datum, horizontal datum, value of safety depth, value of safety contour, magnetic variation, date of issue of the ENC, or chart projection.
S52 7.1 a The system should be capable of performing at least the following calculations: ... transformation between local datum and WGS-84, true distance and azimuth between two geographical positions..., and projection calculations such as true distance, rhumb line, convergence, and great circle.	MARGINAL	Examine FUND for all calculations.	All calculations supported.	Datum transformation and convergence not found. NIMAMUSE applications can supply these.

S52 7.1.b The accuracy of these calculations should be such that there should be no visible distortion on the display between the following: rhumb line and chart data and great circle and chart data.		Non-testable requirement.		There should be no visible distortion when comparing calculated rhumb line and great circle with chart data. Unable to locate any rhumb line or great circles in DNC.
S52 7.1.c All calculations should be based on the largest scale-range data available for the area in the ENC.	PASS	Navigate Through a harbour or approach chart and manually select a general chart.	Alarms should be based on larger scaled charts.	Performed as expected.
S52 7.2.a The units for depth should always be on the same screen as the chart display.	PASS	View units of Depth in the top left corner of display.	Units of Depth should be visible in top left corner of display.	Performed as expected.
S52 7.2.b -Positional data and time; -legend; -object description and associated attributes; -textual information from SENC; -list of abbreviations (from IHO INT-1); -result from navigational computations; -record of ENC updates; -list of categories which are removed from Standard Display; -symbol library (see Appendix 2), should be visual on demand on the same screen as the chart display or on an additional graphic or text display.	MARGINAL	Verify that the required information is visible on demand.	The required information should be visible on demand.	Unable to view a list of abbreviations and symbol library.

S52 7.2.c Navigator's notes should be visible as a result of hand-entry on the same screen as the chart display or an additional graphic or text display.	PASS	Add user notes to the chart by selecting Chart / User Configuration / Mariner. Click the Display toggle and click the text button [Tt]. Click the mouse on the chart and enter notes into the window provided.	Notes should appear on the chart as a layer.	Performed as expected.
S52 7.2.d Alarms and indications.	MARGINAL	See test results of appendices 4 and 5 of IMO Performance Standards for ECDIS.		Alarms not supported in Route Planning.
S52 7.2.e North-up/course-up.	PASS	Verify that the display is shown North-up.	Display should be shown North-up.	Performed as expected.
S52 7.2.f Supplementary information.	PASS	Add user overlays by selecting Chart / User Overlays / Mariner.	User is able to add overlays without degrading from SENC.	Performed as expected.
S52 7.2.g Depth information should be displayed as it has been provided in the ENC and not adjusted by tidal height.	PASS	Determine if there is any function that displays the ENC depth data other than the way it was provided.	Should not be any adjustments by tidal height.	Performed as expected.
S52 8 Minimum configuration.	PASS	Determine if FUND satisfies the minimum configurations required.	Should satisfy all minimum configurations.	Performed as expected.

4.2 S-52 Appendix 1: Guidance on Updating the Electronic Navigational Chart

All updating in FUNDS is yet to be completed due to lack of valid update data. As a result, an evaluation based on this document will not be done at this time.

4.3 S-52 Appendix 2: Provisional Color and Symbol Specifications for ECDIS

REQUIREMENT	RATING
S52 A2 2.2.1 Should be similar to paper chart whenever possible unless otherwise specified. However, ECDIS must switch to a negative image of the chart at night, using a dark background in place of the white background of the paper chart.	PASS
S52 A2 2.2.2 It should be possible to distinguish clearly on the display between a very large number of features. It should also be possible to distinguish between sources.	PASS
S52 A2 2.2.3 Route monitoring display presents only the immediately relevant information clearly and without ambiguity. During route monitoring, alphanumeric characters should be kept to a minimum. Old display should remain visible until the refresh is ready for quick draw.	PASS
S52 A2 2.2.4 Important features should be clear and conspicuous at all times.	PASS
S52 A2 2.2.5 Priority of information: display base, standard display, and other information. -- See Section 3.2 for details.	PASS
S52 A2 2.2.6 Size of lines and symbols should be viewable at 70 cm for route planning. Important chart features should be visible from several meters for route monitoring.	PASS
S52 A2 2.2.7 The overall background colors of the night display must be very dark, which limits the depth zone shades that can be distinguished to only two - deeper than and shallower than the safety contour. If the entire display area consists of only one depth zone an additional pattern is provided to indicate shallow water. In addition, the color fill used to indicate that an area has no chart data is the same as the deep water color by night. It therefore has an added pattern fill of gray squares at night only.	PASS
S52 A2 2.2.9 Rules for displaying text.	PASS
S52 A2 2.2.10 Attracting attention by blinking - better uses for red	PASS
S52 A2 2.2.11 Operator control of information should be effective and simple.	PASS
S52 A2 3.1.1a Some object classes do not have a symbol. They may be referenced by an [I] on the display or stored. Should an "unknown object" occur in the SENC for which no symbol exists, its presence should be indicated by a magenta '?'.	PASS

S52 A2 3.1.1b Updating the Presentation Library	FAIL - This functionality not found.
S52 A2 3.1.2 Symbols should not be drawn smaller than specified in the Presentation Library.	FAIL - The symbols are currently drawn smaller as the scale decreases.
S52 A2 3.1.3a During route monitoring it should be possible to call up additional information quickly and simply when needed.	PASS
S52 A2 3.1.3b During route monitoring the system should acknowledge operator instructions immediately.	PASS
S52 A2 3.1.4 North arrow is required on the display as part of the display base.	PASS
S52 A2 3.1.5 Where charts at different scales overlap, the ECDIS display will show two scale boundaries, at the beginning and end of the overlap, and part of the display will often be grossly overscale.	PASS
S52 A2 3.1.6 Chart data quality information should be available.	PASS
S52 A2 3.2 New symbols for ECDIS (introductory information).	
S52 A2 3.2.1 ECDIS must provide the mariner with the option of using either the traditional paper chart symbols or the new simplified symbols.	FAIL - This functionality not found.
S52 A2 3.2.1 Simplified symbols should be used when the standard display is shown on initial switch-on.	PASS
S52 A2 3.2.2a i Safety contour.	MARGINAL
S52 A2 3.2.2a ii Safety depth.	MARGINAL
S52 A2 3.2.2a iii Isolated dangers.	MARGINAL
S52 A2 3.2.2b(1) Simplified beacon and large beacon tower symbols (except cardinal beacons).	PASS
S52 A2 3.2.2b (2a) Simplified buoy symbols (except cardinal buoys).	PASS
S52 A2 3.2.2b (2b) Cardinal buoys and beacons.	PASS
S52 A2 3.2.2b (3) General symbol for isolated underwater danger of depth equal to or less than the own-ship depth limit.	PASS
S52 A2 3.2.2b (4a) Dredged channel symbol.	PASS
S52 A2 3.2.2b (4b) Dredged area.	PASS
S52 A2 3.2.2b (5) Radar conspicuous coastline.	PASS
S52 A2 3.2.2b (6a) Prohibited area.	PASS
S52 A2 3.2.2b (6b) Indication of caution.	PASS

S52 A2 3.2.2b (6c) Unknown object.	PASS
S52 A2 3.2.2b (7) Information available.	Unable to test.
S52 A2 3.2.2b (8a) Scale boundary shows where the scale of the available chart data changes. This should be marked with two lines, a thin line and a thick line. The thin line is on the small scale side of the boundary and the thick line on the large scale side. A chart index diagram is also required by S-52 (see S52, 6.3a). ECDIS should detect a scale boundary and prepare chart data at the next scale for display. It should also warn the mariner of upcoming chart scale change (see S52, Section 7).	FAIL - Scale boundaries are shown but not with two lines.
S52 A2 3.2.2b (8b) Should a display extending beyond the edge of a relatively large scale chart to include information from the next smaller scale chart, an area pattern should be applied to the entire grossly overscale part of the display. This pattern should not be applied to an overscale display deliberately requested by the operator. The identifying pattern is diagonal gray lines.	FAIL - Not supported.
S52 A2 3.2.2b (8c) Change of units of depth.	Unable to test.
S52 A2 3.2.2b (9) North arrow is required at all times and part of the Display Base.	PASS
S52 A2 3.2.2b (10) Hand-entered corrections.	PASS
S52 A2 3.2.2b (11) The scale bar is a vertical bar, always 1.5 nautical miles in length, divided into three 0.5-mile segments, orange at top and bottom and gray in the middle. It should always be centered next to the left-hand border of the display. It should be displayed at scales of 1:80,000 and larger. A latitude bar should be shown at display scales smaller than 1:80,000 (see S-52 Section 3).	MARGINAL - Has no latitude bar and scale bar is not as described.
S52 A2 3.2.2b (12) Ramark, Racon	Unable to test.
S52 A2 3.2.2b (13) Border for non-HO chart data and End of Chart Data line.	Unable to test.
S52 A2 3.2.2b (14) Identifying pattern for area with no data with gray area shade.	PASS
S52 A2 3.2.2b (15) Identifying pattern for depth areas less than the safety contour. A diamond-shaped pattern of subdued gray lines is provided in the Presentation Library to identify areas of depths less than the safety contour for use as a mariner's option. Mariner should be made aware of the problem of discrimination of depth areas in some situations during the night display.	MARGINAL - Area was gray but no pattern.
S52 A2 3.2.2b (16) Rocky intertidal foreshore.	Unable to test.
S52 A2 3.2.2b (17) Pack ice area.	Unable to test.
S52 A2 3.4 Text as part of the route monitoring display. Alphanumeric information should be used on the route monitoring display only when unavoidable, since it has to be written large enough to be readable and so causes clutter. Sizes, colors, and fonts to be used are specified in the Presentation Library. Alphanumeric characters should always be upright and written horizontally. Some alphanumerics are treated by the Presentation Library as symbols to ensure they are legible and correctly located.	PASS
S52 A2 3.5 Instructions for using a separate text panel on the same screen as the main route monitoring display.	PASS

S52 A2 3.6 Instructions for using a text display on a separate auxiliary screen from the main route monitoring display.	PASS
S52 A2 3.7 The controls and user interaction procedures for ECDIS should be designed following ergonomic principles for user-friendly operation. There should be enough in common from one manufacturer to another that a pilot, or newly joined deck officer, will not experience difficulty in operating an unfamiliar make of ECDIS. The controls should be usable at night without requiring illumination that affects night vision or distracts attention from the main graphics display. A dimmer control should be provided if the controls require lighting.	PASS
S52 A2 4.1.4 Six color tables should be provided to adjust the luminance of the ECDIS display according to the light level on the bridge, under operator control.	PASS

4.4 S-52 Appendix 2: Table One - Colors for ECDIS Features

FEATURE	COLOR	RATING
1. SEA, real features		
coastline	black/white	PASS
area coastline to low water	yellow green (moss-green)	PASS
area dries - safety contour	blue	PASS
area deeper than safety contour	white/black	PASS
dries to selected shallow contour	darker blue/lighter blue	PASS
shallow contour to safety contour	medium blue	PASS
safety contour to selected deep contour	lighter blue/darker blue	FAIL - FUND does not set deep contours.
deeper than selected deep contour	white/black	PASS
safety contour	grey, dominant (thick line)	PASS
other contour	grey, faint	PASS
soundings less/equals safety depth	black/white	PASS
soundings deeper than safety depth	grey, faint	PASS
dredged channel	25% grey, dotted pattern	PASS
dredged symbol	grey	PASS
channel limit	grey, dashed	MARGINAL - Not dashed.
isolated danger symbol	magenta, conspicuous	PASS
dangerous rocks, wrecks, obstructions	black/white	FAIL - Given as a red '?'.
non-dangerous rocks, wrecks, obstructions	grey	FAIL - Given as a red '?'.
ice edge	dashed grey line	Data not found
sea ice	patterned fill	Data not found
rocky intertidal shore	dark brown	Data not found
nature of seabed	grey symbol - small grey font	FAIL - Given as a red '?'.
sandwaves	grey	Data not found
kelp, weeds	grey	Data not found
currents, breakers, overfalls, etc.	grey	

floating drydock, hulk (large scale)	black/white	Data not found
light structures	black/white	Data not found
dolphin, pylon in water, etc.	black/white	FAIL - Given as a red '?'.
logpond	grey, dominant	Data not found
fishing stakes, fish nets, fish farms	grey	FAIL - Color is magenta.
fish havens, fishing beds & grounds	grey, faint	FAIL - Color is magenta.
symbols for fishing features	grey	FAIL - Color is magenta.
offshore rigs, etc.	black/white	FAIL - Color is magenta.
underwater wellheads	grey	Data not found
underwater oil, gas pipeline	dominant grey	PASS
underwater water, sewer pipeline	grey	PASS
underwater cables	dominant grey	PASS
buoys, beacons - full chart symbols	black/white	PASS
buoys, beacons - simplified symbols	black/white outline; red/green/yellow/black fill	PASS
light flares	red, green, yellow	Data not found
illumination for buoy, beacon	magenta, faint	PASS
radar reflector	grey	Data not found
fog signal	magenta, faint	Data not found
racon	magenta, dominant	Data not found
radio station	magenta, faint	Data not found
direction of buoyage	magenta, faint	Data not found
tidal stream table available	magenta	Data not found
isogonic lines	magenta	Data not found
characteristics (of buoy, light)	grey, small font	PASS
descriptions & notes (obstructions)	grey, small font	PASS
depth contour labels	grey, small font, always horizontal.	MARGINAL - User chooses color.
place names	faint grey, med and & lrg font	MARGINAL - User chooses color.

2. SEA, aids & traffic routing features			
leading lines	magenta		PASS
light sectors	grey lines, colored strips		
traffic routing	magenta, dominant, thick lines		PASS
traffic separation zone	50% magenta transparent fill		PASS
traffic direction arrows	magenta pattern fill		Data not found
DW & inshore routes	magenta, dominant		PASS
other traffic routing symbols	magenta		PASS
fairway	magenta, thick		PASS
recommended tracks	magenta, thick		PASS
radar reference line	magenta, thick		PASS
cable ferry route	black/white on magenta, thick		Data not found
free-maneuvering ferry route	magenta		Data not found
prohibited areas	magenta, dominant, thick		PASS
areas for cautions, info notices	magenta, faint, thick		PASS
patterned fill symbols for above	magenta, faint		PASS
pilot station	magenta, faint		Data not found
coast guard station, signal station	magenta, faint		Data not found
boundaries	magenta, faint		PASS
warnings	magenta symbol, pick with cursor for details		PASS
cautions, info notices	magenta symbol, pick with cursor for details		PASS
3. LAND			
natural land areas	light brown		PASS
natural features (woods, swamps)	dark brown		PASS
landforms, contours	dark brown		PASS
glacier coastline	dashed dark grey line		Data not found
glacier, ice caps	grey patterned fill		Data not found
natural coastline	black (day)/grey-white(night)		PASS
artificial coastline	dashed dark grey line		Data not found
radar conspicuous coastline	black/white on top of magenta		Data not found
bridges over navigable waters	black/white, thick		PASS
cables, pipelines over navigable waters	black/white, thick		PASS
overhead clearances	black/white		PASS
wharves	black/white, thick		Data not found

berth nos. on wharf	magenta	Data not found
cranes	black/white	Data not found
dock areas	dark brown	PASS
symbol for fish harb., marinas	magenta, faint	PASS
navigation structures on land - (light towers, notice boards)	black/white	Data not found
conspicuous objects	black/white	Data not found
bridges, cables, etc. over non-navigable waters	dark brown	PASS
causeways, dams, dikes (large scale)	brown outline, dark brown fill	PASS
causeways, dams, dikes (small scale)	dark brown	PASS
built up areas	dark brown	PASS
outlines of towns, etc.	dark brown	PASS
buildings, roads, etc.	dark brown	PASS
buildings at large scale	dark brown outline, brown fill	PASS
symbols on land not of navigation importance (church)	brown	PASS
4. NAVIGATIONAL SYMBOLS		
mariner's caution and information	orange	PASS
mariner's notes	orange	PASS
hand chart corns	orange	PASS
planned route	red, thick, dotted	PASS
course, waypoints, etc.	red	PASS
wheel-over	orange	Data not found
alternate route, including notations	orange, dashed	PASS
mariner's danger highlight	50% red fill	PASS
clearing lines	orange	Data not found
ship to scale	black/white, hull-shaped	PASS
ship symbol (circles)	black/white	PASS
hdg vector	black/white	PASS
co & sp made good vector	black/white	PASS
beam bearing line	black/white	PASS
rate of turn arrow	black/white	Data not found
past track	black/white	PASS
secondary past track	grey	PASS
event mark, times	orange	FAIL - Black.
position lines, fixes	orange	FAIL - Black.
EBL, free-footed	orange	Data not found
VRM, free-footed	orange	Data not found

parallel indexing (VRM & EBL)	orange	Data not found
current vector	orange	FAIL - Black.
cursor (also used as chart cursor)	orange	PASS
5. RADAR		
radar image	green, several intensities	Data not found
radar target info, non-dangerous	green	PASS
radar target info, dangerous	red	FAIL - Flashing Magenta.
6. INFO FROM OTHER SOURCES		
various info about areas	grey transparent fill	PASS
various info about lines, points	blue, yellow lines	PASS
7. INFO ABOUT THE CHART OR THE DISPLAY		
scale bar	orange	PASS
scale boundary	grey	FAIL - Black hashed line.
no chart data available	grey fill, plus grey squares at night	PASS
change in unit of depth	magenta	Data not found
non-HO data, and end of data line	two parallel red lines with red- diagonal hatching	Data not found
text of warnings (datum, etc.)	grey, on border of display or window	PASS
text of cautions, notices	grey, on text display area	PASS
cursor	orange, same as navigation	PASS
8. USER INTERFACE		
background	white/black	PASS
border	grey	PASS
area fill, water	darker blue/lighter blue	PASS
area fill, land	brown	PASS

5. CORRELATION OF FUND PHASE 1 WITH FUND TASKING REQUIREMENTS

REQUIREMENT	RATING	TEST PROCEDURE	EXPECTED RESULT	RESULT / COMMENTS
T 4.1 ALL PHASES				
T 4.1.1 Conform to the Electronic Chart Display and Information System (ECDIS) standards (the ECDIS Performance Standard and S-52) with the exception of S-57 (DX90) capabilities. The FUND project will use the DNC database.	MARGINAL	Verify compliance with referenced documents.	Complies.	Updating not supported. See minor discrepancies in the test of this review.
T 4.1.2 Execute on an HP UNIX Workstation at a reasonable performance with following minimum specifications:	PASS	Execute on a HP UNIX Workstation.	Should execute at a reasonable performance.	Performed as expected.
T 4.1.2.1 Processor performance comparable to HP 750 series (SPECfp-70).	PASS	Determine what processor the system is using.	Should be comparable to HP 750 series.	Performed as expected.
T 4.1.2.2 3GB Hard Disk Capacity	PASS	Determine hard disk capacity.	Should have 3GB of hard disk capacity.	Performed as expected.
T 4.1.2.3 64MB RAM	PASS	Determine the amount of RAM in the system.	Should have 64MB of RAM.	Performed as expected.
T 4.1.2.4 Maximize the portability of the final software product to other UNIX platforms. If any software must be HP specific, NIMA shall be advised.	PASS	Examined software source code and consulted with software developers.	Portability is maximized.	Performed as expected.
T 4.1.3 Execute in "C" software utilizing the X/MOTIF operating in IIP-UX (UNIX).	PASS	Look at source code to determine programming environment.	Should be written in "C" and utilizing the X/MOTIF windowing system.	Performed as expected.
T 4.1.4 Provide full screen display of DNC.	PASS	Determine if the software uses the entire area of the display.	Should use the entire area of the display.	Performed as expected.

T 4.1.5 Allows for Global Positioning System (GPS) input in NMEA 0183 format.	MARGINAL	Connect GPS receiver to computer and set the Position Source to GPS.	Should move the ship to the position given by the GPS.	FUND is hard-coded to work with Starling GPS receiver only; thus unable to configure FUND to match the available Magellan GPS receiver.
T 4.1.6 Provide for independent control of up to four (4) displays dependent upon system resources.	FAIL	Non-supported requirement.		
T 4.1.7 Utilize the NIMA standard selected for VPF updating.	FAIL	No update test data available.		Chart updating not supported.
T 4.1.8 Utilize the NIMA standard selected for symbology.	FAIL	Non-supported requirement.		There is not yet a final standard VPF symbology.
T 4.1.9 Include Software Users Manual.	FAIL	Verify that there is a Software Users Manual.	There should be a Software Users Manual available.	There is no Software Users Manual.
T 4.1.10 Include Software Programmers Manual (SPM) described by DOD-MIL-STD-498 Software Development and Documentation DI-MCCR-80021A will be developed. The SPM shall provide the information required by a programmer or software engineer to incorporate the FUND software. In addition, the SPM shall describe the overall software architecture and development environment.	FAIL	Verify that there is a Software Programmers Manual.	There should be a Software Programmers Manual available.	There is no Software Programmers Manual.
T 4.1.11 Display the logos for NIMA, NAVOCEANO, CNOC, NAVSEA, SPARWAR and others as directed by NIMA.	PASS	Select menu item FUND / About.	Should display a window of logos.	Performed as expected.

T 4.1.12 Incorporate Naval Oceanographic Office's (NAVOCEANO) supplemental layer data to be DNC interoperable with ship's own movement.	FAIL	Non-supported requirement.		
T 4.2 PHASE 1				
T 4.2.1 Route monitoring and Intelligent Screen Refresh (PS10.5):	MARGINAL	See the review in this document concerning Section 10.5 of the IMO Performance Standards for ECDIS.		Failure of safety contour lines. Off-track alarm not supported.
T 4.2.1.1 Automatically update the screen with the current ship's own position.	PASS	While running a demo route, turn on route monitoring using menu item Chart / Configuration / Route Monitoring.	Own ship and route should appear on display.	Performed as expected.
T 4.2.1.2 Automatically use the library with the best scale data.	PASS	Load a FUND Demo and verify that the chart displayed is the largest scaled chart available for that area. (The user can verify the chart displayed by comparing the gray text at the lower right of screen with the library diagram on the back of the CD Case).	The chart scale should be the largest available for that area.	Performed as expected.
T 4.2.1.3 Automatically change screen scale based on the library scale.	PASS	Load a FUND Demo where the route crosses libraries which have different scales.	When the different library is loaded, the screen scale should automatically change to the scale of that library.	Performed as expected.
T 4.2.1.4 Automatically refresh display based on ships distance from the edge of screen.	PASS	Set mode to Non-relative while route monitoring. Using the mouse, drag a corner of the dashed rectangle to a new position.	Own ship position is maintained within the resized rectangle.	Performed as expected.
T 4.2.1.5 Allow operator to manually override the auto library selection.	PASS	Turn route-monitoring off. Under menu item Chart / Configuration / Library, choose any library beside Auto.	Should display the library selected for the current geographical position.	Performed as expected.

T 4.2.2 Voyage Recording (PS10.6):	MARGINAL	See the review in this document concerning Section 10.6 of the IMO Performance Standards for ECDIS.		Information on chart and chart updates is not logged.
T 4.2.2.1 Keep a log of all data from GPS receiver at a minimum interval of 1 minute.		Non-testable requirement.		Did not have the system connected to a GPS receiver; however, the system does keep a log during the route monitoring demo.
T 4.2.2.2 Keep a log of all user changes to screen display.	FAIL	Non-supported requirement.		
T 4.2.3.1 Display a scale bar which represents 1nm, 10nm, 100nm, or 1000nm.	MARGINAL	Find scale bar at left-hand side of display.	Should display scale information.	Scale bar is set at .5nm, 5nm, 50nm, etc.
T 4.2.3.2 Scale bar will be color coded to represent real-world distance.	PASS	Locate scale bar on display.	Scale bar should be on left-hand side of display.	Since FUND does not use a conformal map projection, the scale bar only applies to vertical scale; it only indicates horizontal scale at the equator.
T 4.2.4 Position Information (PS 12.2): Current own-ship latitude/longitude will be continuously displayed on screen.	PASS	Find geographic coordinates at top of display.	Coordinates should represent position of own ship.	Performed as expected.
T 4.2.5 Spatial Query (PS 3): Ability to show all database information on any information displayed on screen.	PASS	While holding the cursor over the desired feature, click the right mouse button.	Spatial Query information should be displayed.	Performed as expected.
T 4.2.6 Base Display and Standard Display (S-52, PS Appendix 2, PS 2.3):	PASS	See the review in this document concerning Section 3.2 and Appendix 2 of the IMO Performance Standards for ECDIS.	Base and Standard display should appear as specified.	Performed as expected.
T 4.2.6.1 Base display shall be as defined in S-52, Appendix 2, 3 rd Edition, COE-CEDD/6/24 Add .1 with IMO features mapped to DNC.	PASS	Compare the base display with the requirements.	Base display should match the requirements.	Performed as expected.

T 4.2.6.2 Standard display shall be as defined in S-52 Appendix 2, 3 rd Edition, COE-CEDD/6/24 Add .1 with IMO features mapped to DNC.	PASS	Compare the standard display with the requirements.	Standard display should match the requirements.	Performed as expected.
T 4.2.6.3 Operator shall be able to select between base display and all or part of the standard display.	PASS	Pressing F2 and F3 toggles between the base and standard displays respectively.	Base and standard display should be displayed.	Performed as expected.
T 4.2.7 True/Relative Motion (PSS 7.2):	PASS	See the review in this document concerning Section 7.2 of the IMO Performance Standards for ECDIS.		True motion is referred to as non-relative in FUND.
T 4.2.7.1 In true motion mode, the chart shall remain in a fixed position on the screen while the ship moves on top of the chart.	PASS	Run a demo while in Non-relative motion mode.	Ship should move on top of the chart.	Performed as expected.
T 4.2.7.2 In relative motion mode, the chart shall move behind the ship while the ship remains at an operator defined position on the screen.	PASS	Run a demo while in Relative motion mode.	Ship should stay in center of display while chart scrolls beneath the ship.	Performed as expected.
T 4.2.7.3 The operator shall be allowed to change the motion mode at any time while route monitoring is active.	PASS	While route monitoring, choose menu item Chart / Configuration / Motion to toggle between Relative and Non-relative motion.	Route monitoring should work in the selected mode.	Performed as expected.
T 4.2.8 Best Scale Data (PS10.3): At each ownship positional update, examine the available libraries and automatically retrieve and display the library with the most accurate data for the current ships position.	PASS	Load a FUND Demo, verify that the chart displayed is the largest scaled chart available for that area. (The user can verify the chart displayed by comparing the gray text at the lower right of screen with the library diagram on the back of the CD Case).	The chart scale should be the largest available for that area.	Performed as expected.
T 4.3 PHASE 2				

T 4.3.1 All other DNC data (PS 3): Ability to display operator defined DNC features which are not part of the Base or Standard displays.	PASS	Add other DNC data by selecting menu item Chart / User Overlays / DNC / Add. Display in the Other display mode by pressing F4.	Selected DNC features should be displayed.	Performed as expected.
T 4.3.2 Route monitoring and Intelligent Screen Refresh (PSS 10.5):	MARGINAL	See the review in this document concerning Section 10.5 of the IMO Performance Standards for ECDIS.		Malfunction in safety contour alarm. Off track alarm not supported.
T 4.3.2.1 Automatically update the screen with the current ship's position.	PASS	Run a demo.	Ship's position should be updated automatically.	Performed as expected.
T 4.3.2.2 Automatically use the library with the best scale data.	PASS	Same as Section 4.2.1.2 above.	The chart scale should be the largest available for that area.	Performed as expected.
T 4.3.2.3 Automatically change screen scale based on the library scale.	PASS	Same as Section 4.2.1.2 above.	As the demo crosses library boundaries, the library loaded should be a chart scale that is the largest available for that area.	Performed as expected.
T 4.3.2.4 Automatically refresh display based on ship's distance from the edge of screen.	PASS	Run demo in Non-relative mode.	Display is automatically refreshed when ship reaches user-set boundary.	Performed as expected.
T 4.3.2.5 Allow operator to manually override the auto-library selection.	PASS	Same as Section 4.2.1.5 above.	Library chosen should be displayed.	Performed as expected.
T 4.3.3 DOD Symbols (PS8): Ability to use DOD VPF Symbol Set.	FAIL			There is not yet a final standard VPF symbology.
T 4.3.4 DOD Colors (PS 8): Ability to use DOD supplied RGB colors sets for VPF data (if available).	FAIL			There is not yet a final standard VPF symbology.
T 4.3.5 DNC Updating (PS 3.9, 4.7): Ability to automatically update DNC using the approved DOD updating methodology.	FAIL	No update test data available.		DNC updating not supported.
T 4.3.6 DNC Update Log (PS 3.9, 4.7):	FAIL	No update test data available.		DNC updating not supported.

T 4.3.6.1 Automatically log data, time, affected CD's, affected libraries, affected charts, etc. of chart updates.	FAIL	No update test data available.		DNC updating not supported.
T 4.3.6.2 Allow user to view log of chart updates.	FAIL	No update test data available.		DNC updating not supported.
T 4.3.7 DNC Date of Issue (PS 3.9, 4.7): Allow user to view per-CD information including date-of-issue, VPF version number, etc.	PASS	Under menu item Chart / Configuration / Library, choose the Browse library.	Should display the desired information.	Performed as expected.
T 4.3.8 Range/Bearing from ownship (PS 10.5.12):	PASS			
T 4.3.8.1 Show range and bearing from ownship to cursor.	PASS	Move cursor around the ship on the display.	Range and bearing from the ship to the cursor should be displayed in the bottom-left corner.	Performed as expected.
T 4.3.8.2 Continuously show range and bearing from ownship to user defined latitude/longitude.	PASS	Once the cursor is at the desired position, type 'a' on the keyboard. The Create Range Bearing Mark window appears. Enter the desired information.	A point with the range and bearing information should appear where the cursor was when 'a' was typed.	Performed as expected.
T 4.3.9 Add/remove DNC information from screen (PS 3.5): Allow user to turn on/off DNC features which are not part of the base display.	PASS	Press F2 to remove all features except Base display. Press F4 to view the added features again.	Should toggle between the Base and Other displays.	Performed as expected.
T 4.3.10 Dead Reckoning (PS 6.1):	PASS			
T 4.3.10.1 Given a speed and heading input, automatically update ownship position based on last known position.	PASS	Select menu item Interface / Position Source / Dead Reckoning to set the interface. Then select menu item Interface / Dead Reckoning to get the Dead Reckoning window. Enter the Position and course of the ship.	System should automatically update the ship's position.	Performed as expected.

T 4.3.10.2 Allow operator to provide manual position fixes.	PASS	Select menu item Interface / Dead Reckoning to get the Dead Reckoning window. Press the Apply button.	Position fix should be generated to the display.	Performed as expected.
T 4.4 PHASE 3				
T 4.4.1 Route Planning (waypoints) (PS 10.4):	MARGINAL	See the review in this document concerning Section 10.4 of the IMO Performance Standards for ECDIS.		Required alarms are not provided.
T 4.4.1.1 Add waypoints based on cursor position or latitude/longitude.	PASS	Position the cursor at the desired location and press 'w'.	A waypoint should be displayed on the screen and appended to the waypoint list.	Performed as expected.
T 4.4.1.2 Move waypoints.	PASS	Move cursor to the waypoint. Press "q" key. Move cursor to new position and the "q" key to move the waypoint.	The waypoint is moved	Performed as expected.
T 4.4.1.3 Delete waypoints.	PASS	Move cursor to the waypoint. Press "f" key. to tag and the "backspace" key to delete.	The waypoint is deleted	Performed as expected.
T 4.4.1.4 Connect waypoints using straight or curved segments.	PASS	Create widely spaced waypoints. Set the line type using menu command Navigation / Planned Route / View Route / View Primary.	Route legs should be drawn either straight or curved (great circle).	Both rhumb line and great circle legs are correctly shown as curved legs on FUND's cylindrical equidistant projection. Paper charts are usually on Mercator projection where rhumb lines appear straight.
T 4.4.1.5 Reverse order of waypoints.	PASS	Navigation / Planned Route / Reverse Route / Primary Route	The waypoint order is reversed	Performed as expected.
T 4.4.1.6 Allow entry/display of alternative routes.	PASS	Open both primary and secondary routes.	Routes should be distinguishable. (Primary route appears in red, secondary in orange.)	Performed as expected.
T 4.4.1.7 Route Checking.	FAIL	Non-supported requirement.		The only way to check a route is to traverse it as a demo route.

T 4.4.2 Day/Night screens (SP 52 Appendix 2): Allow operator to change on-screen colors based on time of day.	PASS	Select menu item Chart / Configuration / Color. Choose the desired setting.	Display should correspond to selection.	Performed as expected.
T 4.4.3 Highlight soundings (PS 3.6, 3.7):	PASS	Have the sounding features displayed while running in demo mode. Set the ship draft so that it is deeper than the soundings.	Sounds should blink and be highlighted when the ship approaches.	Performed as expected.
T 4.4.3.1 Allow operator to turn off soundings greater than a given depth.	MARGINAL	Turn off soundings point features.	Only soundings shallower than the ship's draft will appear on the screen.	Performed as expected; however, this requirement may be describing a setting other than the ship's draft.
T 4.4.3.2 Allow operator to display soundings in different colors based on depth.	FAIL	Non-supported requirement.		
T 4.4.4 Safety Contours (PS 3.6): Automatically display the chart using the appropriate safety contours.	MARGINAL	Non-supported requirement.		FUND does not allow the mariner to set a safety contour but automatically assigns the safety contour as the shoalest contour that is deeper than the ship draft.
T 4.4.5 DNC Update Log (PS 3.9, 4.7):	FAIL	No update test data available.		
T 4.4.5.1 Automatically log data, time, affected CD's, affected libraries, affected charts, etc. of chart updates.	FAIL	No update test data available.		
T 4.4.5.2 Allow user to view log of chart updates.	FAIL	No update test data available.		
T 4.4.6.1 Generate an alarm for excess deviation from planned route.	FAIL	Non-supported requirement.		
T 4.4.6.2 Grounding avoidance alarms.	PASS	Run in demo mode.	Should flash when getting within the set distance from grounding.	Performed as expected.
T 4.4.6.3 Generate an alarm for loss of timely GPS data.	PASS	Use Interface / Navigation Status to show the status.	OFFLINE shows in red when no GPS solution was computed.	Performed as expected.

T 4.4.6.4 Other miscellaneous alarms.	MARGINAL	See the review in this document concerning Appendix 5 of the IMO Performance Standards for ECDIS.		
T 4.4.7 Grounding Avoidance (PS 10.5.3): Automatically detect if ownship will cross a safety contour within an operator defined amount of time.	FAIL	Use menu command Ship / Looking Ahead to set the time.	Contours should flash if the contour depth equals the safety contour or shoaler.	All contour lines in the path of the ship flash.
T 4.4.8 Mariner added information (overlays) (PS 6.2):	PASS	Add User Overlays to the ECDIS display by selecting menu items Chart / User Overlays / Mariner.	User Overlays should be displayed.	Performed as expected.
T 4.4.8.1 Allow user to add a layer of information to the display which could contain: Notes (text), lines, or polygons.	PASS	Same as above.	Same as above.	Performed as expected.
T 4.4.8.2 Support operator defined colors, line-style, and fill pattern.	FAIL	Non-supported requirement.		
T 4.4.9 GPS Interface (6.1): System shall read ownship's position from any NEMA-0183 GPS receiver.	FAIL	Connect GPS receiver to computer and set the Position Source to GPS.	Should move the ship to the position given by the GPS.	FUND is hard-coded to work with Starling GPS receiver only; thus unable to configure FUND to match the available Magellan GPS receiver.
T 4.5 PHASE 4				
T 4.5.1 Data Quality (?): Display information from data quality fields of DNC data.	PASS	Select menu item Chart / Notes - Quality. Charts window appears. Press Request Quality.	Data Quality window appears with desired information.	Performed as expected.
T 4.5.2 Magnetic Variation (PS Appendix 2): Operator shall be capable of displaying the magnetic variation for the current ownship's position.	PASS	Select menu item Navigation / Magnetic Variation.	Should display magnetic variation information.	Performed as expected.

T 4.5.3 Collision Avoidance (PS 10.5.4): System shall use track information from Radar interface to determine potential collisions.	MARGINAL	While running in demo mode, turn on ARPA using the following sequence: Select menu item FUND / Demo, select menu item Edit / ARPA, click on a row in the table, and select Tracking to be 'ON'.	An alarm should be given if the simulated ship is in the path of own ship.	Performed as expected; however, sometimes it seems that the ships come awfully close before an alarm is given.
T 4.5.4 Radar Interface (ARPA) (PS 6.3): Digital data input from a commercial ARPA.		Non-testable requirement.		Can only simulate using the demo mode with ARPA turned on.
T 4.5.5 DNC Update Log (PS 3.9, 4.7):	FAIL	Non-supported requirement.		
T 4.5.5.1 Automatically log data, time, affected CD's, affected libraries, affected charts, etc. of chart updates.	FAIL	Non-supported requirement.		
T 4.5.5.2 Allow user to view log of chart updates.	FAIL	Non-supported requirement.		

6. GENERAL COMMENTS

6.1 Suggestions

These are intended to improve the usability of the FUND software.

1. FUND Phase 4 has very limited on-line help (only hotkey definitions are provided) and no user guide. Both should be provided.
2. The FUND software caches DNC data to the magnetic disk transparent to the user with no user control over the cache size or contents. The user should be able to set a maximum cache size.
3. Route selection and management appears under both Demo and Navigation. This redundancy is somewhat confusing.
4. A toggle key for night / day color would be helpful, as it is hard to switch back to day color in a lighted room.
5. The user interface for adding overlays under menu Chart / User Overlays / DNC / add is complex and confusing.
6. Drawing tools under menu Chart / User Overlays / User Drawn are not completely functional. A pointer tool should be added to select feature for delete, edit, move, or resize.
7. Route planning would benefit from a command to empty the route of all currently contained waypoints.
8. Additional GPS receivers should be supported.
9. DNC should be displayed in a Mercator projection. FUND draws charts on a linear latitude / longitude grid which causes significant distortion of bearings and geographic features.

6.2 Bugs

These were problems that occurred while testing the FUND software.

1. Depth contour lines do not behave properly in grounding avoidance.
2. ARPA contacts ahead of and on same course as own ship do not behave properly.

3. Occasionally while performing route planning and route monitoring concurrently FUND gets stuck in an infinite update loop and has to be terminated.
4. A crash occurred when FUND could not find an 'end' file in 'dnc15/gen15a/obs/____/'. It then went about removing all libraries from memory and then crashed with a segmentation violation. Got another segmentation violation while trying to re-start the program. Had to manually delete all files in the cache directory.
5. During the process of adding numerous DNC user overlays, all area fills turned to gray while lines, points and text still had color. The situation was not corrected by restarting FUND. It was corrected by manually deleting all files in the cache directory.

7. STATUS OF OCEANOGRAPHIC FUND OVERLAYS

This section describes a joint effort by NRL and the Naval Oceanographic Office (NAVOCEANO) to produce a prototype of supplementary oceanographic layers in VPF for use as DNC overlays in FUND.

7.1 VPF Background

VPF is a georelational database format and content specification. It was developed over a period of years by Environmental Resources Research Institute (ESRI) (the developer of the ARCINFO GIS product) under NIMA funding. The first VPF data product, Digital Chart of the World (DCW) was also produced by ESRI. VPF "databases" consist of one or more "libraries". "Libraries" contain data over a specific geographic area at a specific map scale. A "library" is composed of one or more "coverages" which are thematic groups such as population, transportation, aids to navigation, etc. "Coverages" contain one or more feature classes, each of which usually represents a particular feature code in a feature coding scheme. VPF databases may be exploited using NIMA provided Government Off The Shelf (GOTS) software products VPFVIEW and MC&G Utility Software Environment (NIMAMUSE) on a variety of computer systems.

7.2 VPF Toolkit Background

NRL's Digital MC&G Analysis Program (DMAP) has developed an internally used toolkit for producing prototype VPF products. DMAP's VPF Toolkit was used in a previous project to adapt the Search And Rescue (SAR) model software to output in VPF. Software for producing a particular VPF product may be written at a fairly high level making function calls into the VPF Toolkit.

7.3 Generalized Digital Environmental Model (GDEM)

At the suggestion of NAVOCEANO, the first oceanographic data product to be converted to VPF was the Generalized Digital Environmental Model (GDEM), a worldwide, variable resolution database of temperature, salinity, and sound speed profiles from the surface to the sea bottom. The GDEM database was converted to VPF format, written to a CDROM, and passed to NISE-East for use as the oceanographic supplementary to DNC.

There were many ways in which a VPF GDEM database could be organized. Since NRL had only limited experience in designing and producing VPF data products and NAVOCEANO had none, several different design options were developed and implemented. Gradually, during the development effort, more advanced VPF options including spatial indexes and tiling were incorporated to improve the database performance. The organization of the GDEM-VPF database includes 7 libraries, one for each of the GDEM regions. Resolutions vary across the libraries from 5 to 30 minutes of latitude and longitude. The libraries are:

1. Arctic Ocean Region
2. Indian Ocean Region
3. Mediterranean Ocean Region
4. North Atlantic Ocean Region
5. South Atlantic Ocean Region
6. North Pacific Ocean Region
7. South Pacific Ocean Region

Each library has an identical internal organization, consisting of 7 coverages. The coverages and corresponding features are:

1. Autumn Salinity, Temperature, and Sound Speed Profiles
2. Winter Salinity, Temperature, and Sound Speed Profiles
3. Spring Salinity, Temperature, and Sound Speed Profiles
4. Summer Salinity, Temperature, and Sound Speed Profiles
5. Monthly Sea Surface Temperatures Profiles
6. Library Reference
7. Tile Reference

8. CONCLUSIONS

1. Installation and user's guides should accompany the FUND software. On-line help should be improved.
2. Chart updating is not yet supported. Significant deficiencies exist in in the area of alarms and indications. Other minor deficiencies are present.
3. VPF is showing significant potential as a distribution format for oceanographic data products, but FUND software has not yet been adapted to provide the multi-database capability that is required to display the oceanographic data as a chart overlay.
4. In spite of the noted deficiencies, FUND accomplishes it's purpose of proving that DNC can sucessfully be used in ECDIS.

9. REFERENCES

International Hydrographic Organization, *Specifications for Chart Content and Display Aspects of ECDIS*, Special Publication No. 52, 4th Edition, December 1994.

International Hydrographic Organization, *Guidance on Updating the Electronic Navigational Chart*, Special Publication No. 52 Appendix 1, December 1994.

International Hydrographic Organization, *Provisional Colour and Symbol Specifications for ECDIS*, Special Publication No. 52 Appendix 2, October 1993.

International Maritime Organization, *Performance Standards for Electronic Chart Display and Information Systems*, IMO resolution A.817(19), Adopted 23 November 1995.

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